

Particulate Matter—A Particular Concern

Responding to evidence linking exposure to particulate matter smaller than $2.5\ \mu\text{m}$ ($\text{PM}_{2.5}$) with a variety of adverse health effects, the environmental standards for $\text{PM}_{2.5}$ were lowered as part of the Clean Air Act amendments of 1997. But the more protective standards are still years away from full implementation. And judging from the findings of recent NIEHS-funded studies, although U.S. ambient levels of $\text{PM}_{2.5}$ have diminished significantly over the past 20 years, action to further control them won't come a moment too soon.

A team led by George Thurston published research in the 6 March 2002 issue of the *Journal of the American Medical Association* presenting what he calls the strongest evidence to date that long-term exposure to airborne $\text{PM}_{2.5}$ and related products of sulfur oxide air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality. Thurston is an associate professor of environmental sciences at New York University and director of community outreach and education at the university's NIEHS-funded Nelson Institute of Environmental Medicine. Similarly, David Christiani, a professor of occupational medicine and epidemiology at the Harvard School of Public Health, and colleagues published work in the 28 August 2001 issue of *Circulation* and the May 2002 issue of *Epidemiology* showing adverse cardiac effects in young boilermakers exposed to fine particulates at work and at home.

Fossil fuel combustion is the main source of $\text{PM}_{2.5}$ and sulfur oxide pollution in U.S. air. Most of those particles come from older coal-fired power plants, which are increasing in use because they can operate more cheaply than newer, cleaner plants. The old plants benefited from a grandfather clause under the 1970 Clean Air Act that allowed them to continue operating without cleaning up. Of his findings, Thurston says, "This study provides further evidence that we need to close that loophole in order to protect public health."

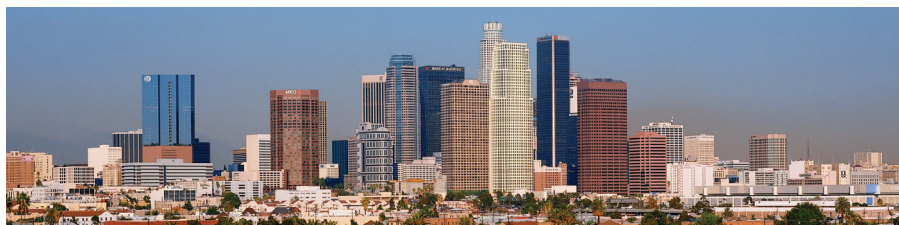
More $\text{PM}_{2.5}$, More Disease

Thurston's team looked at American Cancer Society data on risk factors and cause of death taken over a 16-year period for some 500,000 Americans living in metropolitan areas. They correlated those data with air pollution data for the same areas over the same period. After controlling for risk factors such as smoking, diet, occupational exposure, and geographic variations, they determined that each $10\ \mu\text{g}/\text{m}^3$ elevation in $\text{PM}_{2.5}$ was associated with a 4%, 6%, and 8% increased risk of death from all causes, cardiopulmonary disease, and lung cancer, respectively.

Those startling numbers garnered the most attention when the study was published, but

because they are averaged over all the municipalities studied, they don't completely put the risk in perspective. In the more polluted (and typically more populated) areas of the country, the relative risk is even higher. According to Thurston, the risk associated with living in a large U.S. city translates to about a 20% increased risk of a nonsmoker dying of lung cancer—roughly analogous to the risk faced by a nonsmoker living with a smoker.

With this type of evidence showing that a pollutant to which Americans are exposed on a daily basis is associated with increased risk of cardiopulmonary and lung cancer death, the call to action is clear, says Thurston. "I think this is further confirmation that when we're regulating $\text{PM}_{2.5}$ we're on the right



track—this is the right area for focus—and that the Environmental Protection Agency was right to promulgate the [more stringent] $\text{PM}_{2.5}$ standards."

Of course, the questions at hand are much more complex than when and how to clean up air pollution. As Thurston says, "Energy policy is also health and environment policy . . . and right now we're trying to decide on our energy policy. And making this connection between the power plants and pollution makes clear that those are the choices we're making right now. Are we going to build two thousand more coal-fired power plants over the next twenty years? What we do for energy over the next twenty years is going to have a big influence on environment and health, and I think this paper brings this fact home."

The Long and Short of $\text{PM}_{2.5}$ Effects

Exposure research conducted by Christiani and colleagues adds a different type of evidence to the $\text{PM}_{2.5}$ picture. Their studies focused on the short-term effects on heart rate variability (HRV) in a cohort of young, otherwise healthy workers facing occupational exposure to $\text{PM}_{2.5}$ in addition to ambient exposure. HRV is a standard measurement of alteration in cardiac autonomic function; a decrease is cause for concern. Reduced HRV has been associated with increased mortality among heart attack survivors as well as the general population.

In their studies of 40 Boston boilermakers, they found significant HRV reductions when subjects were exposed to typically high levels of

$\text{PM}_{2.5}$ at work and to ambient levels at home. Their study design let the researchers gather data over longer periods of time and examine the effects of the $\text{PM}_{2.5}$ exposure over those time periods, which in turn helped identify the short- and long-acting components of the adverse cardiac effects. They discovered a dose-response relationship between exposure levels and reduction in HRV, and observed that there appear to be both long-acting (several hours) and short-acting (several minutes) components to the mechanisms involved.

The long-acting component may be related to the production of cytokines, an inflammatory response in the lungs. The short-acting component may be related to a sympathetic stress response from inhaled particles affecting

the autonomic nervous system directly. Although the two components appear to work independently of each other, the researchers found that the association between the length of $\text{PM}_{2.5}$ exposure and the effect on HRV increased as the total duration increased. This suggests either the existence of the longer-term component or a cumulative effect that begins shortly after exposure begins.

Although the long-term clinical significance of this association is unclear, the discovery that even short-term exposure to airborne particulate matter has adverse effects on cardiac autonomic control in young, healthy people is disturbing and warrants further investigation. Christiani hopes to expand his research to include measurements of particles smaller than $1.0\ \mu\text{m}$ and assessment of other physiologic responses to exposure, such as acute-phase reactants in serum, gene expression of inflammatory mediators, and pulmonary effects.

"We're really zeroing in on the earliest stages of the disease process with some of these [effects]," says Christiani, "and I think it's a good place to be, because we're not just going to count deaths or severe disease cases. We're looking at basically the earliest responses we can detect in otherwise healthy people to these particles. . . . The implications are that, in the future, some of the standards we're going to set for environmental exposures may be revised based not just on evidence of mortality, but also on the presence of early markers that predispose people to heart and lung diseases and cancer as a result of particulate exposure." —Ernie Hood

Rising from the Ashes: NIEHS Awards Post-WTC Grants

Just days after the World Trade Center (WTC) and Pentagon attacks on 11 September 2001, the NIEHS began addressing the environmental health impacts of those events. Training grants were awarded to worker safety organizations, labor unions, and New York City Fire Department hazardous materials (HazMat) units, which had suffered heavy losses of key emergency response personnel. In addition, five NIEHS centers received funding to expand research, outreach, and education programs.

Building on those first efforts, Department of Health and Human Services secretary Tommy Thompson announced on 7 May 2002 that \$10.5 million in additional funds has been allocated for 12 NIEHS grant programs. This additional funding is part of the Supplemental Appropriation for Federal Terrorism Response signed into law by President Bush on 10 January 2002, which centers on bioterrorism response and preparedness.

Of the added funds, \$6 million will help further emergency response programs begun last fall. This portion will also be used to educate environmental remediation workers as well as train and certify cleanup workers in the use of personal protective equipment. Finally, these funds will also support specialized training for emergency personnel and remediation workers who may be called upon to respond to future attacks using weapons of mass destruction such as weaponized microbials.

The other \$4.5 million will support research related to the aftermath of the attacks. An exposure assessment will analyze pre- and post-September 11 New York City dust and air samples to determine the presence and concentrations of any potential contaminants, such as lead, asbestos, and particulate matter. Clinical epidemiologic studies will look at any health effects already visible among responders, rescue teams, and residents of the area surrounding the WTC site, and will track these people to determine if any future health effects emerge. Community outreach and health education efforts will focus on health care providers in the lower Manhattan area.

Since September, the group of research grantees has met three times to ensure that their efforts complement one another and to help foster the exchange of information and resources among the projects. One goal of this research program, says Allen Dearth, chief of the Chemical Exposures and Molecular Biology Branch in the NIEHS Division of Extramural Research and

Training, is to establish a central database containing all the exposure analysis information gathered in lower Manhattan by these projects since September 11. The database is still in the planning stages, and will eventually be housed at one of the NIEHS centers participating in this research.



The award recipients are as follows:

- International Association of Firefighters (\$3,205,597): Support additional HazMat technician training and chemical protective clothing/decontamination training for the New York City Fire Department.
- International Union of Operating Engineers (\$1,451,047): Support development of training programs to promote quick and appropriate response by skilled construction and support workers for sites affected by weapons of mass destruction and other disasters. Such programs include a training module on the distribution and fit-testing of respiratory protective equipment at the WTC site.
- The National Puerto Rican Forum and their consortium members at the Alice Hamilton Occupational Health Center, Office of Applied Innovations, and the Maine Labor Group on Health (\$480,000): Train HazMat workers to respond to attacks using weapons of mass destruction.
- University of Medicine and Dentistry of New Jersey School of Public Health (\$398,711): Provide Transit Union workers in lower Manhattan with HazMat technician training. Train members of the New York District Council of Carpenters Labor

Technical College in WTC cleanup activities. Support the New Jersey state police in training HazMat police and hospital workers to effectively respond to emergency situations involving weapons of mass destruction.

- The Laborers-Associated General Contractors Education and Training Fund (\$314,645): Train workers employed on the WTC cleanup and subway reconstruction project. Train non-English-speaking workers in the New York City area who are involved in anthrax remediation sites.

- The Center to Protect Workers' Rights (\$100,000): Continue health and safety training modules for workers at the WTC site, focusing on awareness of existing and new hazards associated with the site during reconstruction.

- Mount Sinai School of Medicine (\$1,309,990): Conduct a health study of 200 ironworkers dismantling the remains of the WTC. Analyze images of the plumes of pollutants formed by the collision, collapse, and burning of the WTC to assess exposures of the immediate area.

- New York University, with Columbia University, Lamont-Doherty Earth Observatory, and the University of Rochester (\$1,240,139): Study respiratory symptoms in 300 New York City firefighters, plus survey and follow up with 6,000 residents, with community outreach including public forums.

- The Johns Hopkins University (\$601,294): Develop a registry of the estimated 3,000–4,000 workers involved in cleanup at the WTC site for study by questionnaires and function tests. Extend outreach to these workers.

- Columbia University (\$432,480): Study pregnancy outcomes and subsequent child development in a sample of exposed women. Analyze samples of air and dust collected between October 2001 and January 2002, and of New York City soils and harbor and lake sediments.

- University of North Carolina at Chapel Hill School of Public Health (\$302,943): Assess a monitoring device used for worker safety. Assess filter samples gathered by the U.S. Environmental Protection Agency at Ground Zero in the weeks following the WTC attack.

- Environmental and Occupational Health Sciences Institute of the University of Medicine and Dentistry of New Jersey/Robert Wood Johnson Medical School (\$563,154): Assess surrounding communities' real and perceived risks, including possible increases in premature births and birth defects, post-traumatic stress disorder, depression, and panic disorders. —Erin E. Dooley